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Astro-Venture: Astronomy Educator Guide

An Educator Guide with Activities in Astronomy and Astrobiology

http://astroventure.arc.nasa.gov

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Astro-Venture:
Astronomy Educator Guide

National Aeronautics and Space Administration
Office of Education

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Introduction

The Astro-Venture Astronomy Lessons have been developed by the National Aeronautics and Space Administration (NASA) for the purpose of increasing students' awareness of and interest in astrobiology and the many career opportunities that utilize science, math and technology skills. The lessons are designed for educators to use with students in grades 5-8 in conjunction with the Astro-Venture multimedia modules on the Astro-Venture Web site <http://astroventure.arc.nasa.gov>.

Astro-Venture Overview

Astro-Venture is an educational, interactive, multimedia Web environment highlighting NASA careers and astrobiology research in the areas of astronomy, geology, biology and atmospheric sciences. Students in grades 5-8 are transported to the future where they role-play NASA occupations and use scientific inquiry as they search for and build a planet with the necessary characteristics for human habitation. Supporting activities include chats and webcasts (live streaming audio and video) with NASA scientists, classroom lessons and NASA occupations fact sheets and trading cards.

Astro-Venture Overall Goal

Astro-Venture uses astrobiology content, the scientific inquiry process and critical thinking skills to increase awareness of NASA careers and to educate students in grades 5-8 on the requirements of a habitable planet.

Astro-Venture Overall Objectives

- Students in grades 5•8 will be able to identify and explain the vital characteristics of Earth which make it habitable to humans.

- Students will use the process of scientific inquiry to explain the methods scientists use to find planets that have characteristics necessary to sustain human life.

- Students will design a planet that has all of the necessary features to support human survival.

- Students will identify at least one NASA occupation that best fits their interests and skills and will identify methods for pursuing a similar career.

Astro-Venture Structure

Astro-Venture is composed of online, interactive, multimedia modules and off-line classroom lessons. The story line and technology components provide the overall purpose and motivation for teaching the standards and concepts in the off-line lessons. The technology components also help to connect students to real science and scientists at NASA.

Astro-Venture is divided into five sections or "Research Areas."
1. Astronomy
2. Geology
3. Atmospheric Sciences
4. Biology
5. Design a Planet

The first four sections have the following components:

Training (The "Whats")

In each of these interactive, online, multimedia modules, students make changes to aspects of our Solar System and make observations of the effects on Earth. They then draw conclusions about the conditions that are required for human habitation in that science content area. In these training modules, students learn **what** humans need in a planet and star system to survive.

Classroom Lessons (The "Whys")

Off-line, students engage in many classroom investigations in which they learn **why** humans need the requirements identified in the Training modules. These lessons have been developed to meet national education standards and build on each other to truly teach standards-based concepts such as: states of matter, systems, the geologic rock cycle, human health systems and atmospheric composition.

Missions (The "Hows")

After completing the training modules and lessons, students will engage in interactive, online, multimedia missions to simulate the methods scientists might use to search for a star system and planet that meet the qualifications identified in the training modules. In these modules, students learn **how** to go about finding a planet that would support human survival.

Design a Planet (Overall Assessment)

Once students have completed the first four sections, they will engage in the online, interactive, multimedia Design a Planet module in which they will design a simulated star system and planet that meets all human survival requirements in all four areas: astronomy, geology, atmospheric sciences and biology.

Project 2061

In addition to meeting the National Science Education Standards, International Society for Technology in Education Standards and National Council of Teachers on Mathematics standards, the Astro-Venture Astronomy Lessons are written to meet benchmarks from the Benchmarks for Science Literacy produced by the American Association for the Advancement of Science (AAAS) as part of their science, math and technology reform movement called Project 2061. The mission of Project 2061 is to "shape the future of education in America, a future in which all students [will] become literate in science, mathematics and technology by graduation from high school" (p. VII). "The Benchmarks for Science Literacy are statements of what all students should know or be able to do in science, mathematics and technology by the end of grades 2, 5, 8 and 12" (p. XI) and are based on extensive research of when and how it is developmentally appropriate to teach the concepts and skills described.

The table below shows how these benchmarks are identified for each lesson. There is a great deal of overlap between the Benchmarks for Science Literacy and the national science and math education standards. Therefore, we have also identified these standards, when appropriate. The first portion of the table entry identifies which standards or benchmarks are referenced. 2061 is a reference to the Benchmarks for Science Literacy. NSES is a reference to the National Science Education Standards. NCTM is a reference to the National Council of Teachers on Mathematics national mathematics education standards. ISTE is a reference to the International Society for Technology in Education standards. The second portion of the table entry identifies the specific standard referenced. In the case of Project 2061, the standard is referenced, the grade range is referenced and finally the number of the concept under this standard and grade range is referenced. We distinguish between "meeting" benchmarks or standards, and "addressing" them to alert educators to concepts that are taught in a lesson or lessons compared to topics or ideas that we might touch upon but do not really teach. Educators may note that often several lessons are required to truly teach a concept. We understand the time constraints of the classroom may not allow for the time that is really needed to truly teach a concept or benchmark; however, it is our goal to model effective instructional methods for science, math and technology. As stated in Benchmarks for Science Literacy, "If we want students to learn science, mathematics, and technology well, we must radically reduce the sheer amount of material now being covered" (p XI).

Example of Lesson Objectives/Standards Table

Objectives	Standards
Students will research and list the basic requirements for human survival in their Astro Journals.	Meets: 2061: 6C 3-5 #1, 2 Addresses: 2061: 4B 6-8 #2
They will write a survival story identifying these basic requirements, the consequences of not meeting them and how they are met.	
After comparing characteristics of the Earth with other planets and moons, students will predict which features of the Earth they believe are crucial to human survival.	

In addition to meeting benchmarks, the Astro-Venture Astronomy Lessons integrate some of the instructional methods that Project 2061 research has identified as being the most effective in teaching science, math and technology. These include:

- Overall Purpose: We provide an overall purpose or goal and connect to this throughout. We base measurable objectives and assessments, which evaluate these objectives on the overall purpose.
- Prerequisite Knowledge/Skills/Misconceptions: We identify prerequisite knowledge and common misconceptions. We alert educators to these misconceptions and provide questions or suggestions on how these might be addressed.
- Variety of Phenomena/Quality of Experiences: We provide a variety of highly interactive experiences and questioning strategies that require higher order thinking skills.
- Introducing Terms: We limit the use of terms and introduce them within context once the concept is understood.
- Welcoming All Students: We strive to make the content accessible to all student populations by providing suggestions for Accommodations for students who might benefit from modifications and Advanced Extensions for students who can benefit from additional challenges. In addition, we incorporate cooperative learning, hands•on activities and total physical response activities to facilitate the learning of students who speak English as a second language and to address multiple learning styles.

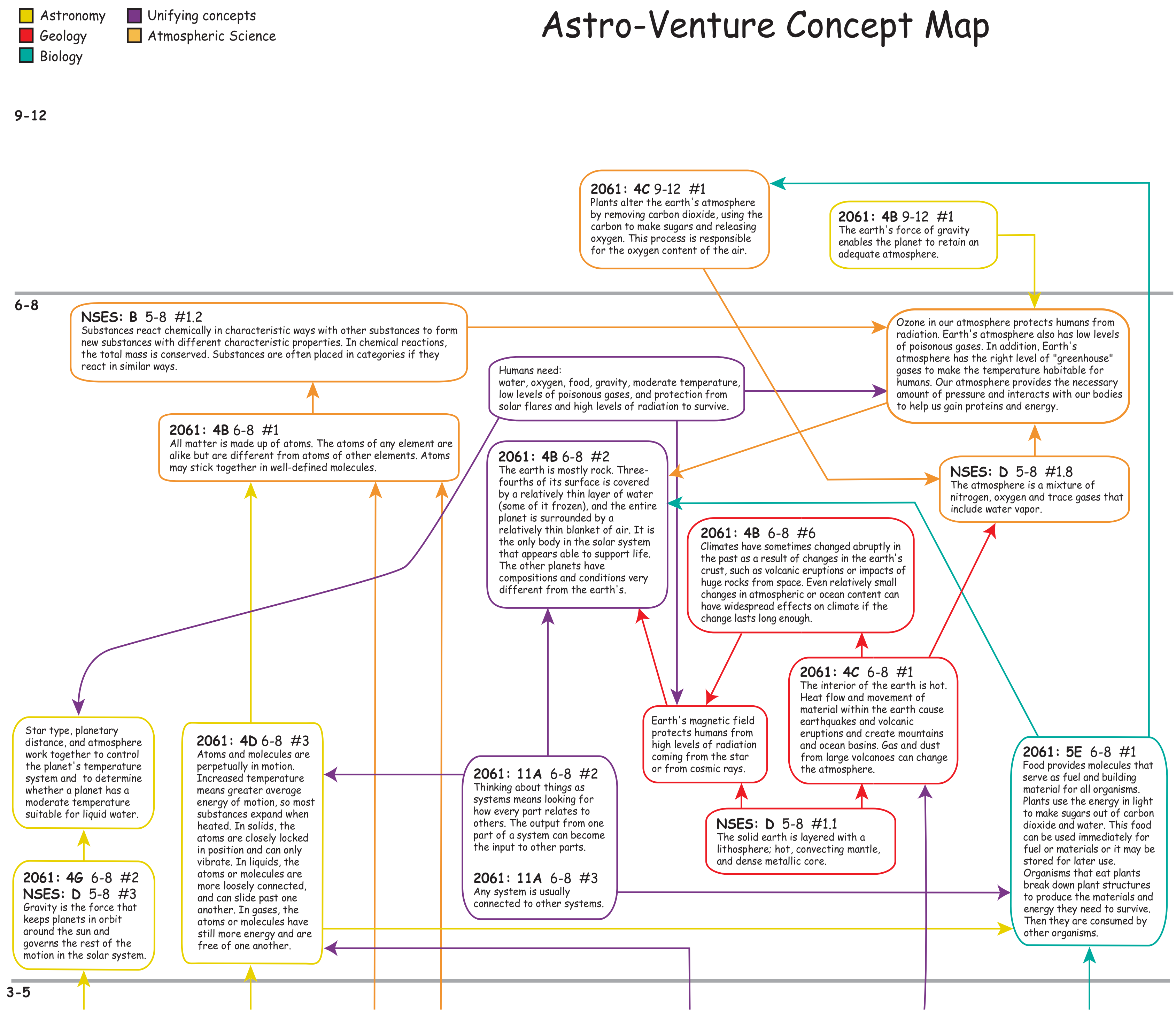
Astro-Venture Concept Map

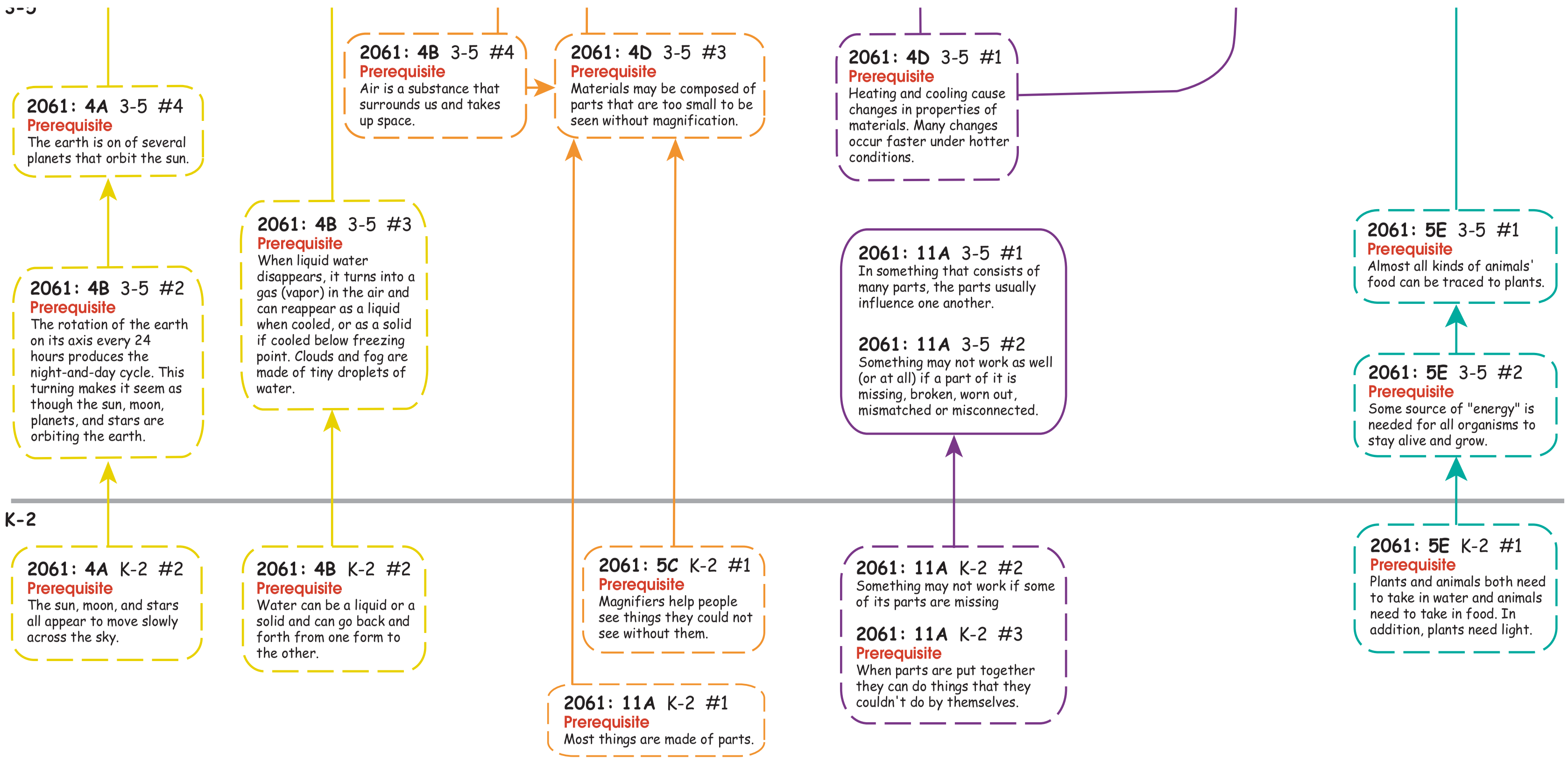
The following map (please see the following two pages) demonstrates the Benchmarks for Science Literacy and National Science Education Standards that have been identified for Astro-Venture. The map shows the overall concepts that are taught throughout Astro-Venture, as well as the benchmarks specific to the different sections. The map also shows the prerequisite benchmarks that students should have mastered prior to learning the benchmarks in Astro-Venture.

More information on the benchmarks and standards referenced can be found at the following Web addresses:

Standard/Benchmark Title	Web Address
American Association for the Advancement of Science: Project 2061	http://www.project2061.org/
National Science Education Standards (NSES)	http://www.nap.edu/readingroom/books/nses/html/
National Council of Teachers on Mathematics (NCTM)	http://standards.nctm.org/index.htm
International Society for Technology in Education (ISTE)	http://cnets.iste.org/
International Technology Education Association (ITEA)	http://www.iteawww.org/TAA/TAA.html

Astro-Venture Concept Map




3-5
K-2
2061: 4A 3-5 #4
Prerequisite
The earth is on of several planets that orbit the sun.
2061: 4B 3-5 #2
Prerequisite
The rotation of the earth on its axis every 24 hours produces the night-and-day cycle. This turning makes it seem as though the sun, moon, planets, and stars are orbiting the earth.
2061: 4A K-2 #2
Prerequisite
The sun, moon, and stars all appear to move slowly across the sky.
2061: 4B 3-5 #4
Prerequisite
Air is a substance that surrounds us and takes up space.
2061: 4B 3-5 #3
Prerequisite
When liquid water disappears, it turns into a gas (vapor) in the air and can reappear as a liquid when cooled, or as a solid if cooled below freezing point. Clouds and fog are made of tiny droplets of water.
2061: 4B K-2 #2
Prerequisite
Water can be a liquid or a solid and can go back and forth from one form to the other.
2061: 4D 3-5 #3
Prerequisite
Materials may be composed of parts that are too small to be seen without magnification.
2061: 5C K-2 #1
Prerequisite
Magnifiers help people see things they could not see without them.
2061: 11A K-2 #1
Prerequisite
Most things are made of parts.
2061: 4D 3-5 #1
Prerequisite
Heating and cooling cause changes in properties of materials. Many changes occur faster under hotter conditions.
2061: 11A 3-5 #1
In something that consists of many parts, the parts usually influence one another.
2061: 11A 3-5 #2
Something may not work as well (or at all) if a part of it is missing, broken, worn out, mismatched or misconnected.
2061: 11A K-2 #2
Something may not work if some of its parts are missing
2061: 11A K-2 #3
Prerequisite
When parts are put together they can do things that they couldn't do by themselves.
2061: 5E 3-5 #1
Prerequisite
Almost all kinds of animals' food can be traced to plants.
2061: 5E 3-5 #2
Prerequisite
Some source of "energy" is needed for all organisms to stay alive and grow.
2061: 5E K-2 #1
Prerequisite
Plants and animals both need to take in water and animals need to take in food. In addition, plants need light.

Astro-Venture Astronomy Section

In the Astronomy section, students begin as Junior Astronomers where they identify human needs for survival and complete the online Astronomy Training module to discover the astronomical conditions of our Solar System that make Earth habitable to humans. When they have successfully completed their training, they earn their badge and are promoted to Senior Astronomer. They then engage in off-line Astronomy lessons to discover why we need the astronomical conditions identified in Astronomy Training. Finally, they proceed to their online Astronomy Mission where they work with NASA scientists to find a star system and planet with the astronomy features that will support human life. Before embarking on further research in other areas, they must summarize their research findings and convince the World Science Foundation (a fictional group made up of their peers) that the planet they have found is worthy of further exploration.

The objective and standards of Astro-Venture Astronomy are broken down into fourteen lessons, as shown in the following table:

Astro-Venture Astronomy Lessons, Objectives and Standards Alignment

Unit Concept: For a planet to support human life, it must have liquid water at or near the surface all of the time. There are astronomical factors, which affect the ability of a planet to have these conditions.

Part 1: Unit Introduction Lessons

Overview of Part 1: Students are introduced to the basic requirements for human survival. Using an online, multimedia module, they change factors of our Solar System and draw conclusions about which factors are necessary for human survival.

Lesson	Main Concept	Scientific Question	Objective	Benchmarks/ Standards
1. Unit Introduction	Humans need water, oxygen, food, gravity, a moderate temperature and protection from poisonous gases and high levels of radiation to survive.	What do humans need to survive? Why?	Students will research and list the necessities for human survival in their Astro Journals. They will write a story about human survival identifying these necessities, the consequences of not meeting them and how they are met. After comparing characteristics of the Earth with other planets and moons, students will predict the features of Earth that they believe are crucial to human survival.	**Meets**: 2061: 6C 3-5 #1, 2 NSES: F 5-8, #1 **Addresses:** 2061: 4B 6-8 #2 NSES: A 5-8 #1 ISTE: 3, 5
2. Astronomy Training Module	Certain astronomical conditions help to meet some of our human survival needs.	What astronomical conditions allow for human survival?	Students make descriptive, un-biased observations of the effects of changes to our solar system on Earth. Students will identify the characteristics of our solar system that allow for human survival.	**Meets:** NSES: A 5-8 #1 ISTE: 3, 5 **Addresses:** 2061: 4B 6-8 #2 2061: 4A 6-8 #1 NSES: D 5-8 #3

Part 2: States of Matter

Overview of Part 2: Students explore the conditions required for water to be in a liquid state. They discover that temperature is the essential variable. They then explore how temperature affects the motion of molecules and molecular bonds.

Lesson	Main Concept	Scientific Question	Objective	Benchmarks/ Standards
3. Properties of Matter	Matter can exist in three states: solid, liquid and gas. Each state has unique properties.	What are the similarities and differences between the properties of solids, liquids, and gases?	Students will identify the properties of solids, liquids and gases and will cite similarities and differences in those properties.	**Meets:** NSES: B K-4 #1 **Addresses:** NSES: A 5-8 #1
4. Matter and Molecules	The properties of matter derive from the bonds between the molecules and the motion of the molecules that make up the matter.	Why do the states of matter have the properties that they have?	Students will explain and illustrate that the properties of matter derive from the connections between molecules. They will demonstrate their learning in a poster.	**Meets:** 2061: 4D 6-8 #3 NSES: B 9-12 #1 **Addresses:** NSES: A 5-8 #1
5. Changing States of Matter	Matter changes state when temperature changes.	What causes matter to change its state and how is this accomplished?	Students will use an inquiry process to identify temperature as the variable that causes a substance to change from one state to another. They will then identify the relationship between temperature and the molecular bonds and movement in a substance. Students will explain the temperature conditions of a planet necessary for human life.	**Meets:** 2061: 4D 6-8 #3 NSES: B 9-12 #5 NSES: A 5-8 #1 **Addresses:** NCTM: 4, 5, 9
6. Measuring Temperature	Temperature is a measurement of the movement of atoms and molecules in a substance. Thermometers using various temperature scales measure temperature.	What does temperature actually measure and how do we measure it?	Students will identify that temperature measures the movement of atoms in a substance. Students will identify the thermometer as the tool and the Fahrenheit, Celsius, and Kelvin scales as the means by which we measure temperature.	**Meets:** 2061: 4D 6-8 #3 NSES: B 9-12 #5 **Addresses:** NSES: A 5-8 #1 NCTM: 4

Part 3: The Planetary Temperature System

Overview of Part 3: Students explore the planetary temperature system. They further explore how each part influences the system and the consequences of disrupting that system.

Lesson	Main Concept	Scientific Question	Objective	Benchmarks/ Standards
7. Thinking in Systems	Systems consist of many parts. The parts usually influence each other. A system may not work as well (or at all) if a part of it is missing, broken, worn out, mismatched or misconnected. Thinking about things as systems means looking for how every part relates to other parts. Any system is usually connected to other systems.	What are the characteristics of a system?	Students will explain: how a system is made up of interacting parts, that when parts of the system change it affects the system, and that systems are often related to other systems.	**Meets:** 2061: 11A 3-5 #1 2061: 11A 3-5 #2 2061: 11A 6-8 #2 2061: 11A 6-8 #3 NSES: UCP K-12 #1 **Addresses:** NSES: A 5-8 #1
8. The Solar System	The solar system is a system. One of the ways that the parts of the solar system interact with each other is through gravity.	How do the parts of the solar system interact with each other?	Students will explain the solar system as a system. Students will explain how gravity affects the solar system.	**Meets:** 2061: 11A 3-5 #1 2061: 11A 3-5 #2 2061: 11A 6-8 #2 2061: 11A 6-8 #3 2061: 4G 6-8 #2 NSES: UCP K-12 #1 NSES: D 5-8 #3 **Addresses:** NSES: A 5-8 #1 NCTM: 2, 5, 9 ISTE: 3, 5
9. Planetary Temperature As A System	The type of star and the distance of a planet from the star affect two major parts of the system that controls the surface temperature of a planet (planetary temperature system). The hotter a star is, the further the planet needs to orbit in order to maintain liquid water on its surface.	What are two important parts of the planetary temperature system? How do these parts work together to determine a planet's surface temperature?	Students will explain how the star type and the distance of a planet from its star affects the planetary temperature system. Students will categorize stars on a Hertzsprung-Russell (HR) Diagram. They will also model the relationship of star type and orbital distance and will draw conclusions about the stars most suitable for supporting human life.	**Meets**: 2061: 11A 6-8 #2 NSES: UCP1 K-12 **Addresses**: NSES: A 5-8 #1 NCTM: 2, 5, 9

Lesson	Main Concept	Scientific Question	Objective	Benchmarks/ Standards
10. Atmosphere and Temperature	The atmosphere of a planet affects the planetary temperature system, which determines the temperature of that planet.	How does atmosphere affect the planetary temperature system?	Students will explain and illustrate that atmosphere can raise the temperature of a planet.	**Meets:** 2061: 11A 6-8 #2 NSES: UCP K-12 #1 NSES: A 5-8 #1 **Addresses:** NSES: A 5-8 #1 NCTM: 4, 5, 9
			Students put together a concept map that shows the parts of the planetary temperature system.	
			Students will explain why atmosphere is important to habitability and how star type, distance and atmosphere all work together to determine a planet's temperature system.	
11. Atmospheric Mass	The amount of atmosphere on a planet depends on the planet's gravity, which is determined by the planet's mass.	What determines the amount of atmosphere on a planet?	Students will explain and illustrate how planetary mass affects atmosphere to effect a change in the temperature of a planet.	**Meets**: 2061: 11A 6-8 #2 NSES: UCP K-12 #1 **Addresses**: NSES: A 5-8 #1 NCTM: 2, 5, 9
			Students will explain why a planet 1/4 to 4 times Earth's mass is a requirement for habitability.	
12. Disrupting the System	If Jupiter were in an elliptical orbit at 1 AU, it could cause a change in Earth's orbit, which would have consequences for the planetary temperature system.	What could happen if Jupiter was in an elliptical orbit at 1 AU?	Students explain how a planet's orbit could be disrupted.	**Meets:** 2061: 11A 6-8 #2 NSES: UCP K-12 #1 **Addresses:** NSES: A 5-8 #1 ISTE: 3, 5
			Students explore the implications of such a disruption on the planetary temperature system and on human habitability.	

Part 4: Unit Conclusion and Evaluation

Overview of Part 4: Students use an online, multimedia module to simulate the techniques that scientists might use to find a star system and planet that meet the astronomical conditions required for human habitability. Students then summarize their learning from this unit in a final project.

Lesson	Main Concept	Scientific Question	Objective	Benchmarks/ Standards
13. Astro-Venture Mission Module Training	Scientists use methods such as spectroscopy, Doppler Shift, photometry and Kepler's Third Law: to collect data from a star. They then interpret this data to determine if the star system has the astronomical conditions required for human habitability.	What are the chances that there is a star system other than our own that has the astronomical conditions required for human habitability? Explain.	Students will use the scientific inquiry process to describe the methods scientists use to find a star system that has the astronomical conditions required for human habitability. Students will compare and analyze data to find a star system that meets the astronomical conditions required for human habitability.	**Addresses**: 2061: 1B 6-8, #1 NSES: A 5-8 #1 NCTM: 5, 9 ISTE: 3, 5, 6
14. Final Project	The astronomical requirements for habitability are not sufficient for sustaining human life on a planet. Additional requirements must be met.	What other requirements must a planet meet to be habitable to humans and how might a scientist determine if a planet meets these requirements?	Students will write a proposal to convince the "World Science Foundation" that the star and planet they found is worthy of further study and exploration. They will include a description of how the planet meets astronomical requirements for habitability, additional requirements that must be met, the benefits of conducting this study and the type of further study they would recommend for determining if the planet meets these additional requirements.	**Addresses**: NSES: A 5-8 #1

Guide to the Parts of the Lessons

Lesson Introduction and Preparation

Each lesson begins with an Overview, the Main Concept of the lesson and the Scientific Question associated with the concept. The lesson breaks down the Objectives as they are aligned with the National Education Standards and describes how these objectives will be evaluated in the Assessment. It further gives an Abstract of the lesson, breaks down the Major Concepts of the lesson and Prerequisite Concepts that students are expected to have mastered before engaging in the lesson. All of this gives the educator a good overview of what will be covered, how it will be taught and assessed.

The first part of each lesson also gives an outline of a Suggested Timeline that is based on 45-minute class periods. Time will vary depending on the educator's pacing and the student levels and dynamics of the class; however, the timeline provides some basic guidelines for the educator. Materials and Equipment and the Preparation of these materials and equipment are also described and listed so that teachers can easily see what they will need to prepare for the lesson ahead of time. Finally, a table provides suggestions on Accommodations for students that may need more support as well as Advanced Extensions for students who may need to be further challenged.

The Five "E's"

The Astro-Venture Astronomy Lessons intend to model the scientific inquiry process by using the Five "E's". These stand for Engage, Explore, Explain, Extend/Apply and Evaluate. The important factor that distinguishes this lesson format from lessons of other content areas is that students are not told a concept, but are led to explore and discover the concept so that once they reach the Explain section they have an experience on which to base the concept. They are then asked to apply this new concept to other situations and are evaluated on their ability to do so.

Throughout the lessons, a Question and Answer dialogue is modeled. Of course, no class will follow this script; however, the dialogue models the kinds of discussions educators should facilitate in an effort to help guide students toward developing their own understanding of the concepts and toward drawing their own conclusions. The dialogue also models questions that stimulate higher order thinking skills rather than rote memorization of facts.

In addition, the lessons also include periodic Notes to Teacher and cues to Misconceptions. The Notes to Teacher provide additional background information or suggestions that may be helpful to the educator. The educator may determine that some of the information is appropriate to share with their students, while other information is not. It is hoped that by alerting the educator to Misconceptions that educators will try to bring out these misconceptions with their students and help their students to address the misconceptions. Misconceptions are one of the most challenging areas for science educators, because research shows that we must disprove our own misconceptions before we can accept new concepts. We cannot be told these concepts, but must discover them ourselves.

Engage

The Engage section of each lesson provides guidelines for drawing on students' prior knowledge, building on previous lesson concepts, introducing the purpose of the lesson and the Scientific Question that will be explored.

Explore

In the Explore section, students make Predictions or Hypotheses in response to the Scientific Question and are given an activity that will help them to collect data and evidence to answer the Scientific Question.

Explain

In the Explain section, students reflect on the explore activity by recording their Results and Conclusions. They discuss these as a class or in small groups and receive feedback on their ideas. They may also engage in readings or additional demonstrations that provide further explanation of the concepts they have explored.

Extend/Apply

In the Extend/Apply section, students are given an activity or assignment in which they demonstrate their understanding of the concept and/or apply it to another situation. Again they receive feedback on their learning.

Evaluate

In the Evaluate section, students are evaluated on their understanding of the concept. Often rubrics are provided for evaluation of this learning. In addition, students discuss and summarize the main concepts of the lesson, which is posted on the wall so students can see how the concepts build on each other.

Lesson Blacklines

The end of each lesson includes the blacklines needed for class set duplication or for creating transparencies for that particular lesson. These can be printed out and duplicated, as needed. Astro Journals are included for most lessons and model the scientific inquiry process used throughout each lesson.

Rubrics

Almost all of the assignments in Astro-Venture have a rubric for evaluation. Generally, these rubrics are included directly on the assignment sheets so that students know what they are expected to do. Before the students begin the assignment, the teacher should go over the rubric so that everyone understands the expectations.

When using the rubrics to evaluate student work, there are a few things to keep in mind that will make the process easier and more effective.

1. The teacher should spend some time thinking about the assignment and the rubric <u>before</u> reviewing it with the students. The teacher's thoughts may change after discussing it with the students, but everyone will benefit from the teacher knowing what she is expecting.

2. The four levels of the rubric describe general levels of proficiency. Few assignments will ever be exactly a '3' or exactly a '2'. Certain expectations will be met more proficiently than others. To assign a score, the teacher should identify the score that "best fits" the work. If there is a great discrepancy, then the teacher can consider multiple scores although this will create more work and difficulties in reporting.

3. Written assignments such as essays focus on content and reasoning. The teacher may also use district standards for evaluating the writing process.

4. Visual assignments such as illustrations do include expectations for the appearance of the illustration. The focus of these expectations is the clarity of the information being presented in the illustration. Despite the great advancements in digital imaging technology, botanists, entomologists, and archeologists (among others) still rely on specially trained artists to record new findings. The ability to express visual information clearly and accurately is a skill worth developing. Appearance <u>cannot</u> substitute for the accuracy of the information, but it can enhance the expression of this information. That enhancement is worth acknowledging.

Scientific Inquiry Evaluation Rubric For Evaluating Astro Journal Entries

There are many ways of approaching rubrics for assessment, each with its own strengths and weaknesses. Whatever the approach the goal is the same, providing feedback for students so that they can meet or exceed the standards or other expectations upon which they are focusing.

With this goal in mind, it is essential that students have many opportunities to work with the rubric: clarifying and analyzing the expectations, going over assessed work to understand the scores, evaluating their own work and their peers' work, and coming up with evidence to explain and justify those scores. Rubrics are only useful as long as they help students to understand how to improve their work and aid in their learning process.

The following rubric for inquiry in the Astro Journal divides the Astro Journal steps into four components and states expectations for each of those components. Scoring is done for each component in reference to the degree to which the expectations are met.

Component	Expectations
Hypothesis/ Prediction	• Clearly stated • Specific enough to be testable/observable and give a meaningful result • Has basis in solid information or observations and a logical reasoning process
Materials, Procedures, and Data	• Clearly stated • Complete • Accurate and tied directly to hypothesis and scientific question
Results	• Clearly stated • Refers directly to Scientific Question and data • Draws a reasonable conclusion from that data
Conclusions	• Clearly stated • States how hypothesis/prediction was confirmed and/or altered • Refers directly to findings, observations, and/or data to explain why thoughts were changed.

Scores:
4: Expectations Exceeded
3: Expectations Met
2: Expectations Not Quite Met
1: Expectations Not Met

The score of '3' indicates that the expectations were met. The score of '4' indicates that the expectations were exceeded. The difference between those two scores is somewhat subjective and should be worked on by each teacher (or group of teachers trying to use the rubric in a standard fashion). The score of '2' indicates that expectations were not quite met while the score of '1' indicates that the expectations were not met. The difference between those two scores is again somewhat subjective, but some thought into the implications of these scores might be helpful in distinguishing between the two. A '2' indicates that the student needs some assistance and work in meeting the expectations. A '1' indicates the student needs much assistance and work in meeting the expectations.

For this reason, just providing the students with a score, especially students with scores of '2' or '1' is not enough feedback. The student needs to know the reasons why a particular score was given. (Note: even students with scores of '3' and '4' benefit from learning why their work received the scores that it did. Many of these students are not conscious of what they did to receive those scores and might not repeat what they did, if it is not made explicit to them.)

Consider the following example. In Lesson 5: Properties of Matter, the students have to develop a hypothesis about what causes matter to change state. Here are three sample (fictional) responses.

(A) Heat causes matter to change its state. I've watched ice cubes melt outside of the freezer and I've watched water turn to steam when you heat it up.

(B) Temperature causes matter to change its state.

(C) Particles go into stuff and energize it because matter is just energy.

Response 'A' is clearly stated and specific enough to be tested leading to a meaningful result. It also has an explanation that is based on solid observation and reasoning. The fictional student is saying that she has made two observations that show a consistent pattern that explains the phenomena – a logical reasoning process. Notice that the hypothesis is not quite correct. Regardless of that fact, the hypothesis should score at least a '3' and possibly a '4' depending on how the teacher and students understand the rubric.

Response 'B' is not grounded in any information or observations and shows no evidence of a reasoning process. In certain ways, it is not even clear. In short, this hypothesis should score only a '2,' and the student should be told to base his hypothesis in more solid information or observations and to indicate how the hypothesis was reasoned from those sources.

Response 'C' is not very clear. The student may or may not have based this hypothesis on solid information, observations, and reasoning. You, as the teacher, just do not know. The hypothesis should score only a '2' or possibly even a '1'. In the long run, the actual score of the hypothesis is less important than the student learning what is needed in order to meet the expectations and put together a good hypothesis.

In conclusion, using this rubric will require an investment of time and energy by teacher and students in creating an understanding of what these expectations mean and how they will be demonstrated in student work. If that process leads to changes in the rubric, so much the better. All the participants in that process will have a richer understanding of the process and will be better poised to engage in authentic inquiry experiences.

Educational Standards List

Benchmarks for Science Literacy (2061)

1 The Nature of Science
A. The Scientific World View
B. Scientific Inquiry
C. Scientific Enterprise

2 The Nature of Mathematics
A. Patterns and Relationships
B. Mathematics, Science and Technology
C. Mathematical Inquiry

3 The Nature of Technology
A. Technology and Science
B. Design and Systems
C. Issues in Technology

4 The Physical Setting
A. The Universe
B. The Earth
C. Processes That Shape the Earth
D. Structure of Matter
E. Energy Transformations
F. Motion
G. Forces of Nature

5 The Living Environment
A. Diversity of Life
B. Heredity
C. Cells
D. Interdependence of Life
E. Flow of Matter and Energy
F. Evolution of Life

6 The Human Organism
A. Human Identity
B. Human Development
C. Basic Functions
D. Learning
E. Physical Health
F. Mental Health

7 Human Society
A. Cultural Effects on Behavior
B. Group Behavior
C. Social Change
D. Social Trade-Offs
E. Political and Economic Systems
F. Social Conflict
G. Global Interdependence

8 The Designed World
A. Agriculture
B. Materials and Manufacturing
C. Energy Sources and Use
D. Communication
E. Information Processing
F. Health Technology

9 The Mathematical World
A. Numbers
B. Symbolic Relationships
C. Shapes
D. Uncertainty
E. Reasoning

10 Historical Perspectives
A. Displacing the Earth from the Center of the Universe
B. Uniting the Heavens and Earth
C. Relating Matter and Energy and Time and Space
D. Extending Time
E. Moving the Continents
F. Understanding Fire
G. Splitting the Atom
H. Explaining the Diversity of Life
I. Discovering Germs
J. Harnessing Power

11 Common Themes
A. Systems
B. Models
C. Constancy and Change
D. Scale

12 Habits of the Mind
A. Values and Attitudes
B. Computation and Estimation
C. Manipulation and Observation
D. Communication Skills
E. Critical-Response Skills

National Science and Education Standards (NSES)

Unifying Concepts and Processes (UCP)

K-12

1. Systems, order and organization
2. Evidence, models and explanation
3. Change, constancy, and measurement
4. Evolution and equilibrium
5. Form and function

Content Standard A: Science as Inquiry

K-12

1. Abilities necessary to do scientific inquiry
2. Understanding about scientific inquiry

Content Standard B: Physical Science

K-4

1. Properties of objects and materials
2. Position and motion of objects
3. Light, heat, electricity and magnetism

5-8

1. Properties and changes of properties in matter
2. Motions and forces
3. Transfer of energy

9-12

1. Structure of atoms
2. Structure and properties of matter
3. Chemical reactions
4. Motions and forces
5. Conservation of energy and increase in disorder
6. Interactions of energy and matter

Content Standard C: Life Science

K-4

1. Characteristics of organisms
2. Life cycle of organisms
3. Organisms and environments

5-8

1. Structure and function in living systems
2. Reproduction and heredity
3. Regulation and behavior
4. Populations and ecosystems
5. Diversity and adaptations of organisms

9-12

1. The cell
2. Molecular basis of heredity
3. Biological evolution
4. Interdependence of organisms
5. Matter, energy and organization in living systems
6. Behavior of organisms

Content Standard D: Earth and Space Science

K-4

1. Properties of earth materials
2. Objects in the sky
3. Changes in earth and sky

5-8

1. Structure of the earth system
2. Earth's history
3. Earth in the Solar System

9-12

1. Energy in the earth systems
2. Geochemical cycles
3. Origin and evolution of the earth system
4. Origin and evolution of the universe

Content Standard E: Science and Technology

K-4

1. Abilities to distinguish between natural objects and objects made by humans
2. Abilities of technological design
3. Understanding about science and technology

5-12

1. Abilities of technological design
2. Understandings about science and technology

Content Standard F: Science in Personal and Social Perspectives

K-4

1. Personal Health
2. Characteristics and changes in population
3. Types of resources
4. Changes in environments
5. Science and technology in local challenges

5-8

1. Personal Health
2. Populations, resources and environments
3. Natural hazards
4. Risks and benefits
5. Science and technology in society

9-12

1. Personal and community health
2. Population growth
3. Natural resources
4. Environmental quality
5. Natural and human-induced hazards
6. Science and technology in local, national and global challenges

Content Standard G: History and Nature of Science

K-4

5. Science as a human endeavor

5-8

1. Science as a human endeavor
2. Nature of science
3. History of science

9-12

1. Science as a human endeavor
2. Nature of scientific knowledge
3. Historical perspectives

National Council of Teachers of Mathematics (NCTM) Standards

STANDARD 1: NUMBER AND OPERATION

Mathematics instructional programs should foster the development of number and operation sense so that all students—

- understand numbers, ways of representing numbers, relationships among numbers, and number systems;
- understand the meaning of operations and how they relate to each other;
- use computational tools and strategies fluently and estimate appropriately.

STANDARD 2: PATTERNS, FUNCTIONS, AND ALGEBRA

Mathematics instructional programs should include attention to patterns, functions, symbols, and models so that all students—

- understand various types of patterns and functional relationships;
- use symbolic forms to represent and analyze mathematical situations and structures;
- use mathematical models and analyze change in both real and abstract contexts.

STANDARD 3: GEOMETRY AND SPATIAL SENSE

Mathematics instructional programs should include attention to geometry and spatial sense so that all students—

- analyze characteristics and properties of two- and three-dimensional geometric objects;
- select and use different representational systems, including coordinate geometry and graph theory;
- recognize the usefulness of transformations and symmetry in analyzing mathematical situations;
- use visualization and spatial reasoning to solve problems both within and outside of mathematics.

STANDARD 4: MEASUREMENT

Mathematics instructional programs should include attention to measurement so that all students—

- understand attributes, units, and systems of measurement;
- apply a variety of techniques, tools, and formulas for determining measurements.

STANDARD 5: DATA ANALYSIS, STATISTICS, AND PROBABILITY

Mathematics instructional programs should include attention to data analysis, statistics, and probability so that all students—

- pose questions and collect, organize, and represent data to answer those questions;
- interpret data using methods of exploratory data analysis;
- develop and evaluate inferences, predictions, and arguments that are based on data;
- understand and apply basic notions of chance and probability.

STANDARD 6: PROBLEM SOLVING

Mathematics instructional programs should focus on solving problems as part of understanding mathematics so that all students—

- build new mathematical knowledge through their work with problems;
- develop a disposition to formulate, represent, abstract, and generalize in situations within and outside mathematics;
- apply a wide variety of strategies to solve problems and adapt the strategies to new situations;
- monitor and reflect on their mathematical thinking in solving problems.

STANDARD 7: REASONING AND PROOF

Mathematics instructional programs should focus on learning to reason and construct proofs as part of understanding mathematics so that all students—

- recognize reasoning and proof as essential and powerful parts of mathematics;
- make and investigate mathematical conjectures;
- develop and evaluate mathematical arguments and proofs;
- select and use various types of reasoning and methods of proof as appropriate.

STANDARD 8: COMMUNICATION

Mathematics instructional programs should use communication to foster understanding of mathematics so that all students—

- organize and consolidate their mathematical thinking to communicate with others;
- express mathematical ideas coherently and clearly to peers, teachers, and others;
- extend their mathematical knowledge by considering the thinking and strategies of others;
- use the language of mathematics as a precise means of mathematical expression.

STANDARD 9: CONNECTIONS

Mathematics instructional programs should emphasize connections to foster understanding. Of mathematics so that all students—

- recognize and use connections among different mathematical ideas;
- understand how mathematical ideas build on one another to produce a coherent whole;
- recognize, use, and learn about mathematics in contexts outside of mathematics.

STANDARD 10: REPRESENTATION

Mathematics instructional programs should emphasize mathematical representations to foster understanding of mathematics so that all students—

- create and use representations to organize, record, and communicate mathematical ideas;
- develop a repertoire of mathematical representations that can be used purposefully, flexibly, and appropriately;
- use representations to model and interpret physical, social, and mathematical phenomena.

International Society for Technology in Education (ISTE) Standards

TECHNOLOGY FOUNDATION STANDARDS FOR STUDENTS

1. *Basic operations and concepts*
   - Students demonstrate a sound understanding of the nature and operation of technology system.
   - Students are proficient in the use of technology.

2. *Social, ethical, and human issues*
   - Students understand the ethical, cultural and societal issues related to technology.
   - Students practice responsible use of technology systems, information and software.
   - Students develop positive attitudes toward technology uses that support lifelong learning, collaboration, personal pursuits and productivity.

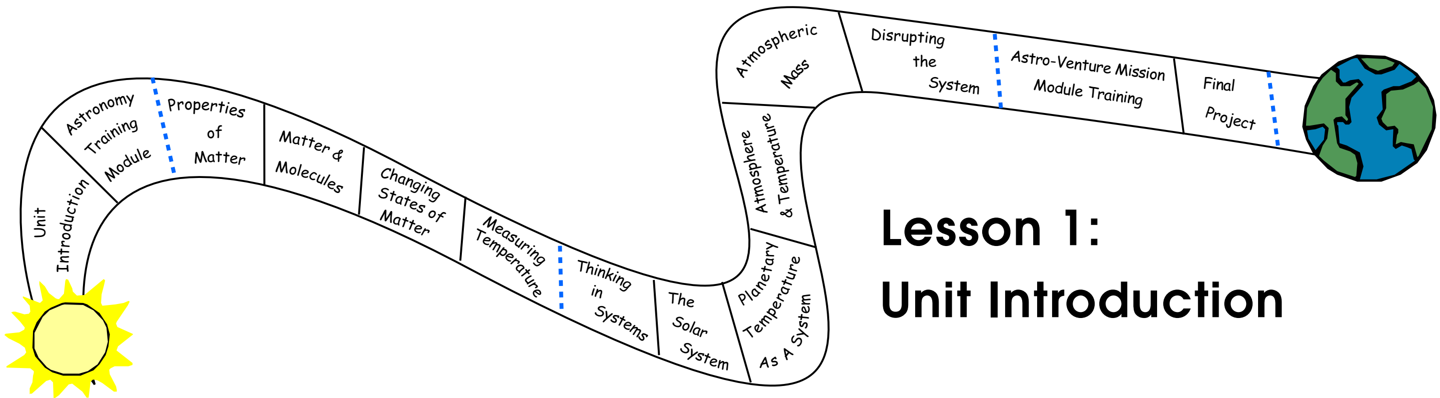
3. *Technology productivity tools*
   - Students use technology tools to enhance learning, increase productivity and promote creativity.
   - Students use productivity tools to collaborate in constructing technology•enhanced models, prepare publications and produce other creative works.

4. *Technology communications tools*
   - Students use telecommunications to collaborate, publish and interact with peers, experts and other audiences.
   - Students use a variety of media and formats to communicate information and ideas effectively to multiple audiences.

5. *Technology research tools*
   - Students use technology to locate, evaluate and collect information from a variety of sources.
   - Students use technology tools to process data and report results.
   - Students evaluate and select new information resources and technological innovations based on the appropriateness for specific tasks.

6. *Technology problem-solving and decision making tools*
   - Students use technology resources for solving problems and making informed decisions.
   - Students employ technology in the development of strategies for solving problems in the real world.

Part 1: Unit Introduction Lessons



Lesson 1: Unit Introduction

Students are introduced to the basic requirements for human survival. Using an online, multimedia module, they change factors of our Solar System and draw conclusions about which factors are necessary for human survival.

Main Lesson Concept: Humans need water, oxygen, food, gravity, a moderate temperature and protection from poisonous gases and high levels of radiation to survive.

Scientific Question: What basic requirements do humans need to survive? Why?

Objectives	Standards
Students will research and list the basic requirements for human survival in their Astro Journals.	**Meets**: 2061: 6C 3-5 #1, 2 NSES: F 5-8, #1 **Addresses**: 2061 4B 6-8 #2 NSES: A 5-8 #1 ISTE: 3, 5
They will write a survival story identifying these basic requirements, the consequences of not meeting them and how they are met.	
After comparing characteristics of the Earth with other planets and moons, students will predict which features of the Earth they believe are crucial to human survival.	

Assessment	Write-up in Astro Journal.
Abstract of Lesson	Students are introduced to the overall goals and concepts of Astro-Venture and are given the background information for the Astronomy unit and final project. Students research the requirements for human survival and analyze the planets and moons in our solar system to assess the ability of each to support human survival.

Prerequisite Concepts	Major Concepts
• Energy is the capacity to do work (make an object move). • Information taken from a book, Web site or other resource is not always accurate. It is important to check the reputation of the source and to find several sources that agree.	• Humans need food, because it gives us energy so that we can move, grow and function. It also gives us nutrients to build and repair bones, teeth, nails, skin, hair, flesh and organs. • Humans need oxygen, because it helps us to obtain energy from sugars. • Humans need water, because it allows nutrients to circulate through the body. It also allows the body to filter out waste and poisons and helps to regulate our body temperature. • Humans need a moderate temperature to prevent the body temperature from going above or below 98.6° F/37°C. • Humans need protection from high levels of radiation and poisonous gases to prevent cancer, disease and damage to the body. • Humans need gravity for normal development and function of our bodies. • Earth is the only planet that we know of that can meet our requirements for human survival.

Suggested Timeline (45-minute periods):

Day 1: Engage and Explore Part 1 Sections
Day 2: Explore Part 2 Section
Day 3: Explain Section
Day 4: Extend/Apply and Evaluate Sections

Materials and Equipment:

- An overhead transparency of the Astro-Venture Academy Letter of Acceptance
- A class set of the Astro-Venture Materials Packets
- A class set of Astro Journal Lesson 1: Unit Introduction *
- A class set of Survival Story
- 1 Planetary Comparison Chart for each group
- A class set of Human Requirements Reading
- Books, CD-ROMs or other resources on human survival needs, human health, biology or astrobiology.
- Chart Paper
- Overhead projector

Preparation:

- Gather resources (i.e., books, CD-ROMS etc.)
- Make overhead transparency of Astro-Venture Academy Letter of Acceptance.
- Duplicate a class sets of Astro-Venture Materials Packets, Astro Journals, Survival Story and Human Requirements Reading.
- Prepare copies of Planetary Comparison Charts for each group.
- Prepare chart paper with major concept of the lesson and human survival needs to post at the end of the lesson.

*Note to Teacher: A generic Astro Journal is included with the Instructional Materials. If you prefer, you can have students use the generic Astro Journal instead of the ones designed to go with each lesson. This might be especially useful for older students who are already familiar with the inquiry method.

Differentiation:

Accommodations

For students who may have special needs, provide extra support for reading assignment (e.g. partner, read aloud, etc.).

Advanced Extensions

- Research what a chosen microbe* needs to survive.
- Create a Venn Diagram comparing and contrasting microbes' needs with human needs.

*Suggested microbes: bacillus anthracis (anthrax) thermus aquaticus or pyrococcus furiosus.

Engage (approximately 20 minutes)

1. Introduce Astro-Venture.

- Project the overhead transparency of the Astro-Venture Academy Acceptance Letter.

- Read over the letter with students. Emphasize the overall concept, goal and purpose of Astro-Venture:

- Question: Why would we be interested in the study of life in the universe?
- *Answers may include: We are interested in the study of life in the universe in order to better understand life on Earth; to find out if life on Earth is unique; to better understand how life began and evolved; or to improve human ability to survive on other planets.*

- Question: Why would we want to study our own planet and star system's ability to support human life?
- *Answer: This will help us understand what kinds of places to look for in the universe that could also support human life.*

- Question: Why might we want to find other planets like Earth?
- *Answers may include: We may want to find other planets like Earth in order to find other forms of life and discover how this life might compare to life on Earth; to find out if we are alone in the universe; or to better understand how our planet, Solar System and life formed and evolved.*

- Say: Your goal as Astro-Venture scientists will be to determine what characteristics of Earth and our Solar System allow humans to survive and to find and design a planet and star system that meet these requirements.

2. Hand out the of Astro-Venture Materials Packets.

Have students read through the materials individually or as a class. Go over the major goals and activities with students.

- Question: What is the major goal of the Astro-Venture Academy?
- *Answer: The major goal of the Astro-Venture Academy is to find, study, and design planets that would be habitable to humans.*

- Question: What kinds of activities will we participate in to achieve this goal?
- *Answer: We will participate in online training modules, off-line investigations, online mission modules, and Design a Planet module to help with this goal.*

- Question: In this unit, we will focus on Astronomy. What are the goals of the Astronomy section of Astro-Venture?
- *Answer: The goals of the Astronomy section are to identify the astronomical features of our star system and planet that support human habitation, why we need these features and how we might go about finding a star system and planet like this.*

3. Introduce the Scientific Question of the lesson.

- Scientific Question: What do humans need to survive? Why?

- Tell students that they will be conducting research to help answer this question.

Explore Part 1 - (approximately 25 minutes)

1. Ask students what they think are basic requirements for human survival.

- Record answers on the board or chart paper. Accept all answers.
- *Answers may include: Humans need food, water, shelter from cold or heat, air or oxygen, love to survive.*

- Question: Looking at this list, is there anything that we could live without?
- *Answers may vary.*

  Note to Teacher: Students may have included things like cookies, TV, house, furniture, car or other luxuries that are nice but not necessary for survival. Allow them to decide which items they agree are really essential for survival. If students listed love or companionship, encourage a debate about whether we could survive without these things. Psychological needs are not a main focus of Astro-Venture; however, they are important to acknowledge.

2. Introduce students to their research assignment.

- Refer to the list of human needs the class has composed.

- Question: Why do we need food? What would happen to us, if we didn't have food?
- *Answers may vary and should be accepted without feedback on whether they are correct or incorrect.*

- Repeat this question for the other elements on the list, and accept all answers without feedback. At this point students are not expected to know why each element is needed.

- Tell students that they will be doing some research of health, biology, survival and astrobiology resources to see if there are any needs they left off their list and to see why we need each element.

3. Have students complete the Prediction section of their Astro Journal.

Explore Part 2 - (approximately 45 minutes)

1. **Have students conduct research on the Internet, CD-ROMs and in books that have topics on health, survival and biology.**
   They should research human survival needs and the effects on the human body when these needs are not met, to see if their predictions were accurate. They should record their findings in the Data section of their Astro Journal and bibliographic information of the resources they used in the Materials section of their Astro Journal.

   - *Web sites*: Have students try key words such as anatomy, physiology, health, biology, human body and nutrition at the following search engines and directories for kids:
     - Yahooligans! http://www.yahooligans.com
     - Ask Jeeves for Kids http://www.ajkids.com
     - Ithaki for Kids http://www.ithaki.net/kids
     - Cyber Sleuth Kids http://cybersleuth-kids.com
     - Kids Click http://sunsite.berkeley.edu/kidsclick

     The following encyclopedia Web sites can also be useful:
     - Columbia Encyclopedia http://www.encyclopedia.com
     - Microsoft Encarta http://encarta.msn.com

Explain (approximately 45 minutes)

1. **Students share and compare their results with a partner or small group.**
   They identify which elements and reasons they have in common and share these with the whole class.

2. **List any new elements on the class list that the class agrees is supported by evidence.**
   Have students share the reasons each element is needed.

3. **Read with students the Human Requirements Reading.**
   Have students answer the reading comprehension questions.

4. Go over the human requirements described in the reading and compare them with the requirements the class listed.

Create a final chart like the one below and post this in the classroom for the duration of the unit.

- Question: What do humans need to survive and why?
- *Answer:* Humans need food, water, oxygen, moderate temperature and protection from poisonous gases and high levels of radiation.

Humans need:	**Reason:**
Food	Gives us energy so that we can move, grow and function. It also gives us nutrients to build and mend bones, teeth, nails, skin, hair, flesh and organs.
Oxygen	Helps us to obtain energy from sugars.
Water	Allows nutrients to circulate through the body, allows the body to filter out waste and poisons and helps to regulate body temperature.
Moderate temperature (Average global temperature below 50° C)	Allows us to maintain an average body temperature of 98.6° F/37°C and to maintain water in a liquid state at all times.
Protection from poisonous gases and high levels of radiation	To prevent cancer, disease and damage to the body.
Gravity	Allows our biological systems to develop and function normally.

5. Students record results and conclusions in the Results and Conclusion sections of their Astro Journal.

Extend/Apply (approximately 20 minutes)

1. Discuss how human survival needs listed on the chart are met on Earth.

- Question: How is our requirement for food met on Earth?
- *Answer:* (Accept all answers without feedback whether they are correct or incorrect.) We gain energy and nutrients from plants and animals that we eat. This energy first comes from the Sun.

- Repeat this discussion for each of the elements on this list. At this point, students may not know all of the answers. They may not know how a moderate temperature is maintained or how we are protected from poisonous gases and radiation. These answers will be discussed throughout Astro-Venture.

2. Introduce the planet comparison activity.

- Divide students into groups. Assign each group a different planet to compare with Earth.

- Have students look at the Planet Comparison Chart and determine whether the planet would be habitable or not. If they determine that the planet would not be habitable, have them explain which factors on the human requirements charts will not be met and why.

3. Students share their assessments as a class.
Based on what students know so far, their assessments should include observations that these planets do not have oxygen, and most have no liquid water and have temperatures that are far too extreme for humans.

Evaluate (approximately 25 minutes)

1. Have students write a story using the Survival Story guidelines and Rubric.
In this story, students should describe a situation in which someone's survival is endangered and why their survival is endangered.

- Go over rubric for story.

2. Students share stories with the class and provide feedback on the accuracy of the survival elements included.

Note to Teacher: After each lesson, consider posting the main concept of the lesson some place in your classroom. As you move through the unit, you and the students can refer to the 'conceptual flow' and reflect on the progression of the learning. This may be logistically difficult, but it is a powerful tool for building understanding. For this lesson, the chart of what is needed and why should also be posted.

Astro-Venture Academy Acceptance Letter

Astro-Venture Academy
World Headquarters

Sky Station 2023

Dear applicant,

After extensive review of your application, the admissions committee is pleased to accept you to the Astro-Venture Academy. At this prestigious academy, you will have the opportunity to train and work with NASA scientists, as you explore the fascinating field of astrobiology: the study of life in the universe. Your research will focus on the search for and design of a planet that will support human habitation.

In preparation for your entrance to the academy, please review the enclosed materials.

Sincerely Yours,

Dr. Wentz

Dr. Wentz
Director of Admissions
Astro-Venture Academy

Astro-Venture Academy Materials Packet

The Astro-Venture Academy

The Astro-Venture Academy is a virtual academy that you can attend using the Internet. Your school is one of a select group of schools and universities all over the world who are working together to study, find and design habitable planets. As a member school, you will be expected to complete the online training and mission modules as well as the off-line classroom explorations. This will be challenging, but the rewards will be great if you succeed in finding and designing a planet that can support human life! Good luck!

Academy Resources

During your studies and research, you will be able to use the academy's many instruments. These include:

- Telescopes that are orbiting the Earth above the atmosphere, where more information can be collected.
- Probes that can be sent out to other star systems and planets.

You will also have the opportunity to interact with many NASA scientists and specialists who will assist you along the way. You will be able to learn about many different jobs in astrobiology by reading these specialists' career facts sheets, collecting their trading cards and interacting with them in live webcasts and chats.

What is Astrobiology?

- How did life begin?
- Are we alone in the universe?
- What is the future of life?

These are the questions that astrobiologists are working to answer. Astrobiology is the study of life on Earth and in the universe. Astrobiologists want to have a better understanding of life on Earth and to find out if life on Earth is unique. They study all life forms on Earth. They are especially interested in microbial life, which can only be seen with a microscope. They are interested in studying microbes because they were the first life forms on Earth. Also, many microbes have the ability to live in extreme environments that are too hot or too cold for human survival or the environments have no oxygen. At the Astro-Venture Academy, we focus on human life, so that we can have a better understanding of ourselves and our own survival requirements.

Research Areas

At the Academy, you will explore four research areas:

1. Astronomy
2. Geology
3. Atmospheric sciences
4. Biology

Training

In each of these online modules, you will be trained on the requirements for human habitation that relate to that area of science. In these modules, you learn **what** humans need in a planet and star system to survive.

Investigations
Off-line, you will engage in many classroom investigations in which you will learn **why** humans need the requirements identified in the Training modules.

Missions
After your training, you will engage in online missions to search for a star system and planet that meet these qualifications. In these modules, you learn **how** to go about finding a planet that would support human survival.

Design a Planet
Once you've completed all four sections, you will engage in the online Design a Planet Module in which you will design a simulated star system and planet that meets all human survival requirements in all four areas: astronomy, geology, atmospheric sciences and biology.

Astronomy
As a Junior Astronomer, you will complete the online Astronomy Training module to discover the astronomical features of our Solar System that make Earth habitable for humans. When you have successfully completed your training, you will earn your badge and be promoted to Senior Astronomer. You will then engage in off-line Astronomy investigations, and you will discover why we need the features identified in Astronomy Training. Finally, you will proceed to your online Astronomy Mission where you will work with NASA scientists to find a star system and planet with the astronomy features that will support human life.

Final Astronomy Project
If you are successful in finding a planet and star system that meets the astronomical requirements for human life, write a proposal to the World Science Foundation to convince them that the star and planet you find is worthy of further study and exploration. Include evidence of why the star and planet needs further study, what we could learn from this study and what type of further exploration you would recommend.

Featured Astronomy Careers
The careers featured in this unit are astrophysicists and astrobiologists. You will learn about the following areas of specialty in astrophysics:

- Spectroscopy
- Doppler Shift
- Photometry
- Habitable Zone

The following career fact sheets give more detail about these careers and people in these careers.

Astrobiologist

Related Job Titles:

Exobiologist, life scientist, space scientist

Job Description:

Astrobiologists study life in the **universe**: how it began, where it's located and how it has evolved or changed over time. Three main questions drive their research: How did life begin and evolve? Is there life elsewhere in the **universe**? What is the future for life on Earth and beyond? Astrobiologists need to understand how many different kinds of science work together. These kinds of science may include **biology** (**microbiology**, **botany**, **physiology**, **zoology**), **chemistry**, **physics**, **geology**, **paleontology** and **astronomy**. Some astrobiologists spend time writing proposals to ask for funding for their research. They usually work regular hours in laboratories and use **microscopes**, computers and other equipment. Some use plants and animals for experiments. Many do research outside, and many work with a team.

Interests / Abilities:

- Do you enjoy doing experiments?
- Are you interested in how animals and plants function?
- Are you curious about whether there is other life in the **universe**?
- Do you work well on your own?
- Do you work well with a team?
- Do you enjoy investigating mysteries or problems?

Suggested School Subjects / Courses:

- Science (**biology**, **chemistry**, **physics**, **astronomy**, **planetary science** with **laboratory** research and **fieldwork**)
- Math

Education / Training Needed:

The minimum education required for this position is a **bachelor's degree** in **biology**, **astronomy**, **space science**, **chemistry** or another appropriate subject from an accredited **college** or **university**. This course of study must include at least 20 semester hours of **physical science** or **engineering** or experience that leads to the understanding of the equipment used for manned aerospace flights. To do research, a **Ph.D.** is highly desired for this position.

Areas of expertise:

- ***Chemical and biological evolution***: study what life is, where it's located, how it began and changed over time
- ***Biogeochemistry***: study rocks for evidence of life
- ***Microbiology***: study microscopic organisms and the conditions of the environments where they can survive (especially very hot/cold environments)
- ***Solar system analysis***: research and design new experiments and instruments to explore the **Solar System**

Additional Resources:

- NASA Office of Space Science
  http://www.hq.nasa.gov/office/oss
- NASA Office of Life and Microgravity Sciences and Applications
  http://www.hq.nasa.gov/office/olmsa
- Astrobiology at NASA
  http://astrobiology.arc.nasa.gov
- The Astrobiology Web
  http://www.astrobiology.com
- NASA Specialized Center of Research and Training (NSCORT)/Exobiology
  http://exobio.ucsd.edu
- American Institute of Biological Sciences
  http://www.aibs.org
- American Physiological Society
  http://www.faseb.org/aps
- Biotechnology Industry Organization
  http://www.bio.org/welcome.html
- Biophysical Society
  http://www.biophysics.org/biophys/society/biohome.htm

What can I do right now?

- Join a local environmental club or organization.
- Participate in Earth Day activities.
- Take summer jobs or internships at parks, farms, plant nurseries, laboratories, museums or camps.
- Visit <u>Astro-Venture</u> regularly to participate in chats and activities.
- Call the American Association of Science and Technology Centers for information on science museums in your area that you might visit.
  (202) 783-7200
- Participate in science fair projects.

Astrophysicist

Related Job Titles:

Space scientist, astronomer, research scientist, physicist, planetary scientist, space physicist, dynamicist, planetary spectroscopist, galactic astronomer, stellar spectroscopist

Job Description:

Astrophysicists study objects in the universe including galaxies and stars to understand what they are made of, their surface features, their histories and how they were formed. To study these bodies, astrophysicists often come up with new tools and ways to investigate them. Astrophysicists spend most of their time in laboratories and offices looking at a lot of information gathered by instruments such as telescopes, sensors and probes, deciding what the information means and writing papers and reports about what they find. Some also spend time discovering rules about how objects in space are formed or structured. A small portion of an astrophysicist's time is spent actually making observations with instruments. This may require travel to faraway locations and is done at night.

Interests / Abilities:

- Do you enjoy math and science?
- Do you have a good imagination?
- Do you work well on your own?
- Do you enjoy working with computers?
- Do you enjoy solving mysteries or problems?
- Do you enjoy learning about new things?
- Do you do well in math and science?

Suggested School Subjects / Courses:

- physics
- chemistry
- astronomy
- electronics
- mathematics

Education / Training Needed:

The minimum education required for this position is a **bachelor's degree** in **physics**, mathematics, **astrophysics**, **astronomy** or a related subject from an accredited **college** or **university**. This study must include one **physics**, or **engineering** lab in aerospace instrumentation. To do research, a **Ph.D.** is highly desired for this position.

Areas of expertise:

- ***Solar studies***: study the Sun
- ***Stellar studies***: study the Sun and other **stars**.
- ***Planetary studies***: study **planets**, **moons**, **asteroids**, **meteoroids** and **comets**
- ***Optical physics***: design and develop instruments that measure radiation
- ***Atmospheres and ionospheres***: study atmospheres on Earth, other **planets** and **moons**.
- ***Fields and particles***: study magnetic, gravitational and electric fields in space

Additional Resources:

- SETI Institute Online (Search for Extraterrestrial Intelligence)
  http://www.seti.org
- American Institute of Physics
  http://www.aip.org
- The American Physical Society
  http://www.aps.org
- American Astronomical Society
  (request a pamphlet with information on careers in astronomy)
  http://www.aas.org
- Yvonne Pendleton's Astronomy Web site for students
  (Yvonne is a NASA astrophysicist)
  http://web99.arc.nasa.gov/~yvonne
- The Planetary Society
  http://www.planetary.org
- Astronomical society of the Pacific
  http://www.aspsky.org

What can I do right now?

- Visit Astro-Venture regularly to participate in chats and activities.
- Visit a planetarium or observatory near you.
- Call the American Association of Science and Technology Centers for information on science museums in your area that you might visit (202) 783-7200.
- Join an astronomy club.
- Buy an inexpensive telescope and study the stars from home.
- Read Astronomy and Sky and Telescope magazines.
- Ask your teacher to sign up for Astro, a program where astronomers visit your classroom.
- Attend U.S. Space Camp for a week-long program on astronomy and space sciences.

Astrophysicist

Dr. Yvonne Pendleton

Astrophysicist

NASA Ames Research Center

I think of problems to solve, propose solutions, use the telescope to gather data, analyze the data and present the results in scientific journals and at conferences.

How I first became interested in this profession:

I was inspired by the Apollo Program. I lived in Key West, Florida until I was thirteen, and I remember watching the Apollo rockets on clear days, as they arched overhead from their Cape Kennedy lift-off. I would stand there looking upward, promising myself that someday I would be a part of NASA, the great agency that could take us into space.

What helped prepare me for this job:

As a teenager, I spent every spare minute at the Fernbank Science Center in Atlanta, Georgia, where I was surrounded by scientists. In college, I was often the only woman in my aerospace engineering classes. I found out I was a very determined person, and that helped me overcome obstacles that being in a male-dominated environment presented. College life was demanding and there was little time off. I wish I would have known then what I know now -- that the long hours and hard work were well worth it.

My role models or inspirations:

My sister has always been a role model, because she got her Ph.D. in statistics and inspired me to stay in school. The scientists at the Fernbank Science Center were also a great source of inspiration to me.

My education and training:

- Ph.D. in Astrophysics
- M.S. in Aeronautics and Astronautics
- B.S. in Aerospace Engineering

My career path:

- Twenty years as an astrophysicist at NASA

What I like about my job:

I get the freedom to be as creative as I can be, scientifically. I get to choose the projects I want to investigate. The universe is a puzzle and I get to find some of the pieces.

Areas of expertise:

- Infrared astronomy
- Star and planet formation
- Interstellar dust

What I don't like about my job:

I sometimes have to deal with government rules and responsibilities that take time away from my research.

My advice to anyone interested in this occupation:

Long hours and dedication to your studies now will put you in a good position later, so don't take the easy road. Follow your dreams and believe in yourself. Even when you think you aren't good enough for the task ahead of you, be confident. You'll surprise yourself!

Research Scientist

Dr. Michael Kaufman
Assistant Professor
San Jose State University

Research Scientist
NASA Ames Research Center

I make computer models of the chemical and physical makeup of the regions around new stars. Basically, I "teach" the computer how gases near the stars heat up, move, and change. I then compare the computer model to the observations of other scientists to see if they match up. I also teach classes on astronomy at San Jose State University.

Areas of expertise:

- The formation of stars

How I first became interested in this profession:

I liked the space program when I was in grade school. Looking at the stars always fascinated me.

What helped prepare me for this job:

Math and physics courses have been a big help for me. Also, good teachers helped prepare me by teaching me how to think and by showing me the kinds of jobs I can have once I got these skills.

My role models or inspirations:

I was greatly inspired by my teachers and professors. They had a passion for science, and they loved their jobs.

My education and training:

- M.S. and Ph.D. in Astrophysics, Johns Hopkins University
- B.A. in Physics, Middlebury College

My career path:

- Researcher at NASA on the National Research Council Fellowship for three years
- Assistant professor at San Jose State University for two years

What I like about my job:

I like being able to combine teaching with exploring things that nobody's ever seen before.

What I don't like about my job:

I don't like the business end of things like faculty meetings and/or anything that takes me away from teaching or research.

My advice to anyone interested in this occupation:

Do well in math and physics. It's easier to do well if it's something you love. You should also be pretty comfortable with computers.

Dawn McIntosh
Engineer

NASA Ames Research Center

I'm an Engineer. The group I work with does work with both the International Space Station and the Space Shuttle. I'm working on a 3D simulator of one of the labs on the ISS. Scientists will be able to prepare a science experiment, practice it with the simulator, and save it to be used by the astronauts for training. Then the astronauts can show up, watch the scientist's version of the experiment, and practice it themselves. There's also a 2D simulator that they can bring up to the ISS with them. They can use it for review before actually running the experiment. Others in my group are working to improve the docking between the ISS and the Space Shuttle.

Areas of expertise:

- 3D simulation
- Earth Atmosphere Studies
- Astrophysics
- Physics
- Astronomy

How I first became interested in this profession:

When I was in Junior College, I had no idea what to do for a career. I liked English, Shakespeare, Photography, Ceramics, and Math. Science was OK, but not my favorite. One of my friends talked me into taking a basic astronomy course, even though I didn't need it to graduate. I fell in love with the class (My friend dropped it). I knew after taking that class that I wanted to learn everything I could about Astronomy.

What helped prepare me for this job:

When I finished my Bachelor's Degree, I applied for a job at NASA Ames as a contractor. I was hired by the Earth Science department and worked with a group studying the Earth's atmosphere. After a couple of years, I applied for a civil servant position (means I work for the federal government rather than a company) as an Engineer at NASA Ames. That was only 6 months ago. I'm still figuring out how to do my new job, and it's been fun learning a whole new field.

My role models or inspirations:

I have lots of role models. My parents, who taught me the importance of family, and the value of hard work. My sister, because she is one of the most capable people I know. My husband, because he is so easygoing, loves science, and laughs all of the time. Dr. Adrienne Cool, an astrophysicist, has been one of my role models for years. She helped me learn how to do research, which is a lot different from studying books about science. It's also much more fun. Dr. Tim Castellano is an astronomer I know. He came back to college and became an astronomer after he'd already had a career in a different field. Dr. Yvonne Pendleton is an excellent astronomer at NASA Ames. She spends a lot of time teaching children about astronomy, which I believe is just as important as learning astronomy for yourself.

My education and training:

- B.S. in Astrophysics, San Francisco State University
- Engineering Studies at Stanford University

My career path:

- Contractor, working on Earth's Atmosphere Studies at the Earth Science Department, NASA Ames Research Center
- Aerospace Engineer at NASA Ames, working on a 3D experiment simulator for the International Space Station (ISS)

What I like about my job:

I like the challenge of discovering new things. It's both fun and frustrating, exciting and irritating to figure out how to make a computer program do what you want, and to analyze data and find out something you didn't know before. But the best feeling in the world is when you finally figure out a problem you were are working on. You feel relieved and thrilled all at once.

What I don't like about my job:

It takes a long time to learn something new, and that's hard for me, I like instant answers (those don't happen very often).

My advice to anyone interested in this occupation:

Adrienne Cool has a sign above her desk at San Francisco State University that says: "Think, think, read, think, read, think." This is what it takes to understand and do science. Also, choose a career that you love. Have you heard that before? Probably, but that's because many people don't follow the advice and then regret it. There are parts of science that I find really hard, but I always stuck with it. Mostly because I love it, and also because I'm super-stubborn.

Astrophysicist

Dr. Ed Prather
Research Scientist with the Conceptual Astronomy and Physics Education Research (CAPER) Team
University of Arizona

The main focus of my work is on the topic of astrobiology—the search for life in the universe. Over the last two years, I worked at Montana State University as the NASA CERES Astrobiology Project Coordinator. This summer I moved to Tucson, Arizona, where I now work as a Research Scientist for the Conceptual Astronomy and Physics Education Research (CAPER) team in the Department of Astronomy at the University of Arizona. I spend the majority of my time teaching courses, conducting research into student beliefs and learning difficulties, and on developing new activities to help students learn about astronomy and physics.

Areas of expertise:

- Astronomy & Physics Education Research
- Physics, Earth & Space Science Curriculum and Course Development
- Faculty/Teacher Professional Enhancement Programs
- K–14 Public Outreach
- Online Course Development and Instruction

How I first became interested in this profession:

As a child and a teenager, I liked taking things apart to learn how they worked. In high school, I focused on auto-shop instead of science and math. I then worked as an auto mechanic, and started racing cars and motorcycles, but soon realized that I could not make a living as a professional racer. In my early twenties I decided to go back to school. I immediately fell in love with physics. I was amazed that there was a subject that described how the entire physical world around me worked. Studying physics helped me understand how my race cars and motorcycles operated. For me, the best part of learning physics was working in groups with other students. Along the way, I also discovered astronomy. My career was set, I was going to get a Ph.D. in Physics and teach.

What helped prepare me for this job:

The years I spent working on cars and motorcycles helped prepare me for a career in science. To be successful in repairing machines you must become an expert problem solver. You develop the ability to think of a system in terms of both its separate components and as group of interconnected processes. These skills are tremendously valuable when thinking about the physical relationships studied in physics and astronomy. My experience as a technical writer was also very valuable. Part of being successful in science involves your ability to communicate complex ideas clearly and effectively.

My role models or inspirations:

I am inspired by people that have a strong sense of commitment to their beliefs, and who have the passion and will to carry out their dreams. My first physics teacher has always served as my role model for teaching, he was the best. I also admire Leonardo da Vinci, Albert Einstein and Richard Feynman.

My education and training:

- AA degree, Bellevue Community College, Bellevue, WA
- B.S. in Physics and Astronomy, University of Washington
- Ph.D. in Physics, University of Maine

My career path:

- Three years as technical writer for Genie Industries, Redmond, WA
- Four years as research and lead graduate teaching assistant at the University of Maine, Orono, ME
- Two years as instructor in the Physics Dept. at Montana State University
- Two years as Project Coordinator for NASA CERES Astrobiology Project at Montana State University, Bozeman, MT

What I like about my job:

Personal Freedom!! Overall I like everything about my job. I feel lucky to be a scientist. My job provides me with the opportunity to work with a wide variety of intelligent, passionate, and very interesting people, while also having the chance to be creative, and think very deeply about cutting edge topics at the horizon of scientific discovery. For myself, the most exciting and rewarding part of my job is the opportunity to work with students—sometimes as their teacher, and other times as a researcher trying to uncover the difficulties they have when learning about physics and astronomy.

What I don't like about my job:

I find that having to continuously look for funding for my research, takes me away from my work. I would also like to see that more of our national budget is dedicated to educational efforts in science.

My advice to anyone interested in this occupation:

Find a topic that excites you, and then pursue your dreams with passion and dedication. Believe in yourself, don't worry about what other people think, and your dreams can come true.

Aerospace Engineer

Kelly Snook
Aerospace Engineer, Planetary Scientist, Project Manager
NASA Ames Research Center

I make computer models of Mars, and then compare them to the actual data that we get from the planet. I also do field work, which means I travel to different parts of the world to carry out my research. I recently traveled to the Canadian Arctic in order to test different ways to explore Mars, with which it shares some similarities. I tried on new space suit designs, and rode around on all-terrain vehicles to simulate being on Mars. Because I am a project manager, I also have to do a lot of organizing and paperwork!

Areas of expertise:

- Mars atmosphere
- Manned Mars exploration

How I first became interested in this profession:

I really wanted to go into music, but I thought success might depend more on how lucky I was, than on how hard I worked. One day, I wrote all the professions I could think of on pieces of paper, and I drew engineering out of a hat. Aerospace Engineering sounded interesting. I decided to stick with it, and that became my job.

What helped prepare me for this job:

Working at NASA while doing my Ph.D. work gave me an idea of what working here would be like; I also met many of the people I'd be working with in the future. Hands-on, and project oriented courses have also been very useful in preparing me to build and design.

My role models or inspirations:

One of my role models was my Ph.D. advisor, who guided me through the process of starting to work here. Another major inspiration is Albert Einstein, who had a balanced approach to science and spirituality. I am also very inspired by my religion, the Baha'i Faith; its teachings of harmony between science and religion have motivated me to do well in my work, and through my work, to make the world a better place.

My education and training:

- Ph.D. and M.S. in Aeronautics and Astronautics, Stanford University
- B.S. in Aerospace Engineering, University of Southern California

My career path:

- Eight years as a research/teaching assistant at Stanford University
- Five years as a consultant at NASA Ames
- Two years as an Aerospace Engineer at NASA Ames
- One year Co-Op at the Aerospace Corporation while an undergraduate

What I like about my job:

I like to think about how my work fits in the greater picture of human endeavor and progress. I also enjoy having a job that is exciting, and inspiring, and which allows me the freedom to do what interests me, and the flexibility to do it how and when I want to.

What I don't like about my job:

I don't like spending hours filling out forms, or doing other things that take me away from the task I'm here to do. Looking for the money to support my research, can also be time consuming and frustrating.

My advice to anyone interested in this occupation:

Be persistent. Get a good foundation in math, physics, biology, and geology. Don't lose sight of the things that inspire you, so you'll always be motivated to do your job well. Make sure to take public speaking, and technical writing courses, in order to get other people also interested in your work and ideas.

Astro Journal Lesson 1: Unit Introduction

Class/Period:

1. Scientific Question:

What do humans need to survive? Why?

2. Hypothesis/Prediction: What do humans need to survive? Why?

3. Materials: List the title, author, date and URL (if applicable) of each resource you used to find your Data.

Name:

Date:

4. Data: List elements that humans need to survive and explain why? (List only those elements that you can support with evidence from a reputable book, CD-ROM, Web site or other resource.)

Astro Journal Lesson 1: Unit Introduction

Name:

Class/Period:

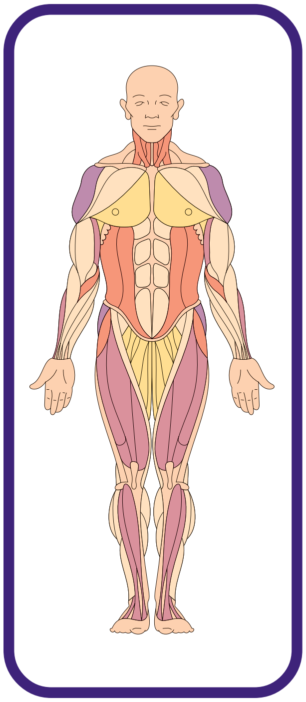
Date:

Data Collection (continued):

6. Results: What do humans need to survive? Why? (Create a revised list below based on what you learned from other members in the class and the Human Requirements Reading.)

7. Conclusions: Compare and contrast your predictions and results. How did conducting research change your original ideas?

Human Requirements Reading



Humans have a few basic needs for survival. These include energy sources (food, plants, the Sun), nutrients, water, oxygen and a moderate **temperature**. Humans also need protection from poisonous gases and high levels of **radiation**.

Food gives us energy. When we eat food, some components of food are broken down into sugar for energy. Our bodies use the sugar to make the energy we need to move and grow. Energy allows all of our organs to function, allows us to move, talk, run, think, breathe and do all of the things we do every moment. Food for humans is like electricity for a computer. Without electricity, a computer cannot do anything. Without energy, our bodies cannot do anything.

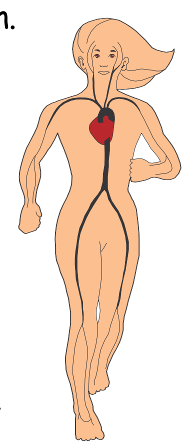
We cannot gain our energy directly from the Sun, so we have to eat plants that gather their energy from the Sun. Animals also gain their energy from plants, so we can also gather energy by eating animals. Therefore, humans need plants and the Sun's energy to survive.

Nutrients from food build and mend our bones, teeth, nails, skin, hair, flesh and organs and allow us to grow. We need to have a well-balanced diet in order to have all of the nutrients that our body needs.

We can't get energy from sugar without oxygen. When we breathe oxygen, it is carried throughout our body in the bloodstream to all parts of the body and into the cells where energy is made.

Humans need an average of two quarts of water a day. Our bodies are 60-70 percent water. Water is in our blood, our cells, our tissues and body fluids. Water allows nutrients to circulate throughout the body and allows the body to filter out waste and poisons. Water also allows the body to regulate its temperature. Without water our bodies become dehydrated. If you have ever run for a long time on a very hot day and became very thirsty, you might have been experiencing a little dehydration. Dehydration can become much worse. For example, sometimes when people have the flu, they can become dehydrated and have to go to the hospital. Humans can survive only about three days without water. In comparison, humans can last thirty days without food.

Humans cannot survive very cold or very hot temperatures. Humans must maintain an average body temperature of 98.6° Fahrenheit/37° Celsius. When our body temperature goes above this, we sweat to cool ourselves down. When our body temperature goes below this, we shiver to generate heat. However, our body cannot correct for very large temperature changes. If we are exposed to very cold temperatures, our bodies lose their heat, and we can die from **hypothermia**. If we are exposed to very hot temperatures, we can die from heat stroke.

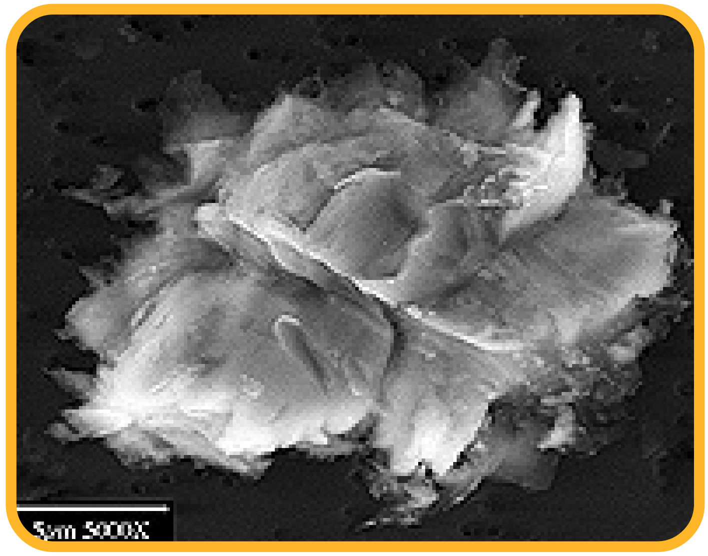


Humans must also be protected from harmful gases and too much radiation. An atmosphere with poisonous gases would kill us. Likewise, we need protection from high levels of radiation that come from the Sun and from exploding stars. We especially need protection from **solar flares,** because they can be unpredictable and release a lot of radiation. High levels of radiation break down the tissues in plants and animals, causing cancer and eventually death.

Although humans can survive for as long as a year in microgravity, the effects of microgravity on our bodies have led scientists to conclude that gravity is important for normal development and function. Without gravity, our bones and muscles shrink and become weak. We lose bodily fluids and red blood cells needed to deliver oxygen and remove waste throughout the body. Fluids in our ears float, so that we become disoriented and confused, and we experience motion sickness. We do not know the range of gravity that is needed for our bodies to function normally, but too much gravity would also have negative effects on our bodies.

It is interesting to note that some living things can exist with different requirements than humans. There are **microbes** that can live in extremely cold or extremely hot environments, can obtain their energy from volcanic vents rather than from the Sun or other living things and are able to bear higher levels of ultraviolet radiation than humans.

If we have all of the essential things described in this reading, our bodies can function normally; however, some scientists would argue that this would not be enough. They point out that humans have psychological needs, too. Humans need interaction with other humans, for example. A big problem for astronauts who spent a lot of time on the Mir Space Station was that they missed their families a lot. There are scientists whose entire job is just to design the International Space Station so that it is a pleasant environment for scientists. They look at how to design the structure, select colors that are pleasing and to include plants to make the environment more comfortable for astronauts.



Exotic-looking microbe found in Antarctic ice.

Questions

(Answer on a separate sheet of paper)

1. What are three things humans need?
2. Where does our energy come from?
3. Why do we need oxygen?
4. What would happen to our bodies without water?
5. Why is the temperature of Earth important to human survival?
6. Do all living things need the same things as humans? Explain.

Survival Story

On a separate sheet of paper, write a story about a person whose survival is endangered. Stories must include references to human survival needs:

1. Describe all of the necessary elements for human survival and how each of these elements is threatened.
2. Describe the consequence of not having each element.
3. Describe how the hero faces and overcomes these challenges to find each element that s/he needs.

Your story will be evaluated using the following rubric.

4	• Story clearly and accurately explains all human survival requirements. • Story has all required parts and uses examples and reasoning to create an exceptionally powerful and detailed explanation.
3	• Story clearly and accurately explains all human survival requirements. • Story has all required parts, makes specific references to examples, and uses good reasoning in explanations.
2	• Story is not completely clear or accurate in explaining the human survival requirements. • Story has most required parts, makes some specific references to examples, and uses some good reasoning in explanations.
1	• Story is not clear or accurate in explaining the human survival requirements. • Story is incomplete, makes few specific references to examples, and uses little or no good reasoning.

Planetary Comparison Chart

Planet	Atmo-sphere	Mass Earth = 1	Diameter *(Radius)* (km)	Density gm/ m^3	Liquid Water	Average Temperature	Force of Gravity Earth = 1	Atmospheric Mass (kg)
Mercury	very little: argon, neon and helium	0.06	4,878 *(2,439)*	5,430	too hot for surface water	day: 350°C/662° F night -170°C/ -274°F	0.38	2.03×10^{8}
Venus	carbon dioxide	0.82	12,104 *(6,052)*	5,250	too hot for surface water	465°C/869°F	0.90	1.41×10^{21}
Earth	nitrogen, oxygen	1.00	12,755 *(6,378)*	5,520	liquid water on the surface	15°C/59°F	1.00	5.33×10^{18}
Moon	none	0.01	3,476 *(1,738)*	3,300	no liquid water	sunlit side: 134°C/ 273°F dark side: -153°C/-243°F	0.17	0
Mars	carbon dioxide	0.11	6,790 *(3,395)*	3,940	Mars may have once had surface water, but doesn't now. Ice has been detected at the North Pole.	-23°C/-9.4°F	0.39	3.09×10^{16}
Jupiter	hydrogen, helium	318	142,796 *(71,398)*	1,314	some water vapor and ice crystals in the atmosphere	-150°C/-238°F	2.53	2.6×10^{22}
Saturn	hydrogen, helium	95	120,660 *(60,330)*	690	some water vapor and ice crystals in the atmosphere	-180°C/-292°F	1.06	4.4×10^{22}
Uranus	hydrogen, helium	15	51,118 *(25,559)*	1,290	some water vapor and ice crystals in the atmosphere	-221°C/-391°F	0.93	7.8×10^{21}
Neptune	hydrogen, helium	17	49,528 *(24,764)*	1,640	some water vapor and ice crystals in the atmosphere	-235°C/-391°F	1.18	7.4×10^{21}
Pluto	methane	0.002	2,300 approx. *(1,150)*	2,030	Any water is frozen as ice.	-220°C/-364°F	0.07	variable